

latter were electrically heated, their temperatures being read by mercury thermometers. The zero positions of the small suspended system were deduced by noting the turning points as read by a distant telescope and scale. Thus the relative gravitative effects with the large masses cold and hot are found by observing the shift in each case on rotating the large masses from the one attracting position to the other.

Elaborate precautions were taken to avoid various disturbances or spurious effects. Those dealt with are electrostatic, magnetic convection, radiometer pressure, occluded gases, damping, radiation pressure, conduction of heat, and displacements of apparatus. Taking all circumstances into consideration, a pressure of 14 mm. was held to be most satisfactory and was adopted in many of the later experiments. The results of the experiments with the final form of apparatus are summarized in the table [not reproduced here]. From this it is deduced, for the given temperature range of the larger masses (of about 47 kg. each) if a linear relation be assumed, that

$$f = G(1 + a\theta)Mm/d^2,$$

where a is a temperature coefficient of value $(+1.20 \pm 0.05) \times 10^{-5}$ per degree C.—*E. H. B[arton]*.

GRAVITATION AND TEMPERATURE.³

By J. L[ARMOR].

[Reprinted from Science Abstracts, Sect. A, Aug. 25, 1916, §801.]

As the outcome of a very delicate systematic series of experiments, it is announced by P. E. Shaw [see above] that when one large mass attracts a small one the gravitative force between them increases by about 1/500 as the temperature of the large mass rises from, say, 15° to 215°C.; that is, it increases by about 1.2×10^{-5} of itself per degree C. This seems to be a very startling result, at any rate if temperature is merely the expression of internal molecular motions, as indeed the experimenter seemed to admit.

By Newton's principle gravitation between masses must act reciprocally; the result, therefore, means that the astronomical mass of a body must increase with temperature by 1.2×10^{-5} of itself per degree C.

The pendulum experiments of Bessel and recent determinations by Eötvös seem to establish proportionality between gravitational mass and mass of inertia, irrespective of temperature, well beyond these limits. Thus inertia also would have to increase with temperature, and when a freely moving mass is becoming warmer its velocity must be diminishing, for its momentum must be conserved. A comet like Halley's is heated upon approach to the sun; thus it should suffer retardation in the approaching, and acceleration in the receding part of the orbit, enough, probably, to upset existing astronomical verifications.

Electrodynamic theory does establish unequivocally an increase of inertia of a body arising from gain (SE) of thermal or electric energy; but this is only of amount SE/c^2 , where c is the velocity of radiation, and so is minute beyond detection. The question whether there is also an equivalent increase in gravitational mass evades discussion until some link connecting gravitative and electric forces has been established.—*E. H. B[arton]*.

³ Review in Nature, London, June 15, 1916, 97:321, of the paper by P. E. Shaw abstracted above.

ICE CRYSTALLIZATIONS FROM AQUEOUS SOLUTIONS.¹

By R. HARTMANN.

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The solutions contain cane sugar, glycerol, alcohol, NaBr, MnSO₄, NaOH, FeCl₃, or HCl, etc., in water, and are undercooled, with the two last-mentioned solvents to -38° and -40°C. The crystallites then separating are of four or five types: (a) The skeletons or nuclei are hexagonal or rectangular in outline, but the three or two (rectangle) axes cross in both cases at 60; (b) and (c) spherulites, radial or built up of plates; (d) feathery growths. With moderate undercooling (a) is obtained; (b) and (c) with heavy undercooling; (d) in very dilute solutions, whatever the cooling. In order to see whether the nuclei have all the same melting points, they were placed in water at -2° and then very slowly heated up, differences of 0.001 degree C. being observable; the melting points were always found normal. In the case of the two (a) types, the linear velocity of crystallization was further determined; no differences were observed. When, in the spontaneous crystallization, a nucleus happens to settle on the glass surface with its base, a hexagon seems to be formed; when with its triangular edge a rectangle is formed.—*H. B[orns]*.

THE KATA THERMOMETER AS A MEASURE OF THE EFFECT OF ATMOSPHERIC CONDITIONS ON BODILY COMFORT.²

By C.-E. A. WINSLOW.

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The readings of an ordinary thermometer afford a poor indication of the degree of comfort felt by the average individual, who in addition to feeling the effects of temperature is also sensitive to air movements. To obtain a more satisfactory measure of comfort L. Hill devised the kata-thermometer outfit, which consists of two thermometers with large bulbs and stems graduated from 86° to 110°F., one to be read as a dry- and the other as a wet-bulb thermometer. The bulbs are heated to about 110°F., and then, while they are freely exposed, the time taken to fall from 100° to 90°F. is noted. The author has taken three series of readings with the apparatus under different circumstances. At the same time a band of observers estimated the degree of comfort of the conditions on an arbitrary scale of 1 to 5, in which 3 represented ideal conditions and 1 and 5 extremes of cold and warmth, respectively. The comparative instrumental and personal results are set out in tables and on a diagram. As a result it seems clear that the instrument is of great value in measuring the actual influence of air conditions on the body and is greatly superior to the ordinary thermometer for this purpose. The curves show that conditions of maximum comfort are represented by falling times, from 100° to 90° F., of 45-60 seconds for the wet-bulb, and 150-180 seconds for the dry-bulb.—*J. S. Di[nes]*.

BALL LIGHTNING ON PUY DE DÔME.³

By E. MATHIAS.

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On April 15, 1916, the phenomenon of ball lightning was observed on three occasions—at 18^h 20^m, 18^h 30^m, and 18^h 50^m—taking the form of a brilliant fireball with somewhat hazy contour, afterwards changing to an oval

¹ Zeitsch. f. Anorg. Chem., Aug. 6, 1914, 88:129-132.

² Science, New York, May 19, 1916 (N. S.), 43:716-719.

³ Comptes rendus, Paris, Apr. 25, 1916, 162:642.